

MODELS OF QUALITY COSTS CALCULATION AND THEIR CLASSIFICATION

Wojciech SADKOWSKI

Jagiellonian University, Cracow; wojciech.sadkowski@uj.edu.pl, ORCID: 0000-0003-2757-6643

Abstract: Quality costs calculation is a tool companies use to measure quality costs. The origins of interest in the field noted in foreign literature and practice date to the end of the 1960s, while in Poland the subject has been known since the 1970s. The purpose of the paper is to present and classify selected models of quality costs calculation. The consequences of the undertaken research work will be the organization of knowledge about models of this calculation, and the specification of the key elements used to build them. Quality costs calculation is the subject of the research. In order to achieve the pursued research objective the critical analysis method was applied to the literature on the subject in the areas of quality management and management accounting, as well as to selected journals. The present paper forms a body of theory with which to develop the author's own model of quality costs calculation.

Keywords: classification, quality costs, model, quality costs calculation.

1. Introduction

Cost accounting is most frequently interpreted as the whole of the activities in an accounting system, such as recognition (measuring and documenting the course of processes), measurement (measuring, documenting and evaluation of resources used in processes), grouping (recognizing and establishing costs by type, origin and final carriers), processing, presenting and interpreting (preparation of reports about costs and results), and analysing, expressed in quantities and in terms of value results of an organization's resource consumption processes in relation to its economic activity (Jarugowa, Malc, Sawicki, 1983). It also embraces planning (budgeting), achievements control, and generating information used for the assessment of the financial position, and for making both operational and strategic decisions. Cost accounting is a system providing information *ex post* and *ex ante* (Jaruga, Kabalski, Szychta, 2010).

In its enhanced definition cost accounting can be considered as a costs and results accounting system involving the study and transformation of information on the costs and

revenues of past, present and future activities, in line with the implemented model, in order to support the management of organization (Jaruga, Kabalski, Szycha, 2010). However, quality costs calculation enables us to single out quality-related costs, and is the foundation aimed at calculating, planning and steering these costs.

The cost accounting model covers a set of assumptions and rules, together with procedures allocated to them, on the basis of which information on costs is processed according to the needs of information recipients. Each of the models has specified assumptions determining the data processing method (Nowak, 2017). The quality costs calculation model is a set of assumptions and procedures which form the foundation for generating data about quality costs. The model of this calculation outlines the structure of quality costs, presents the plan of accounts where these costs should be recorded, indicates sources of information about these costs, and identifies the individuals responsible for keeping this account.

The main objective of the present paper is to classify selected quality cost calculation models on the basis of the adopted division criterion. The author addressed the issue of quality costs as they form a significant element of the managerial accounting system in a company, and their calculation is an integral part of the system for managing it. Moreover, the literature provides access to numerous quality costs calculation models. However, there is no available classification for organizing them and allowing us to single out their key elements.

The paper is divided into three main parts. In the first one the author explains the essence of quality costs calculation. The second part presents a classification of quality costs calculation models. And in the final part an attempt is made to perform a critical analysis of selected models. Conclusions from the considerations are included in the summary.

2. Essence of quality costs calculation

Quality costs calculation is acknowledged as the most important element of the quality management system in companies. It forms an individual part of the cost accounting of an entity (Nowak, 2014). It is a system for registering, analysing and evaluating costs related to ensuring quality at each stage of product manufacturing and in all carried out processes. What is more, it is also regarded as a system for undertaking activities aiming at quality improvement and at quality costs optimization (Ciechan-Kujawa, 2005). It is also a tool combining a company's intentions to optimize production, commercial and management processes with the necessity to use new management methods in order to identify and eliminate company weaknesses and to ensure high quality of provided products and services (Astapczyk, 2011).

Furthermore, it is also a decision making account, held in organizations on the basis of cost information used in making economic decisions (Sulowska, 2012). In quality-oriented companies quality costs calculation is one of the key decision-making tools (Balon, 2007; Balon

2012). It streamlines quality management in organization and is a significant element of the economic analysis of an organization. It is a source of information on reasons for incurring specified quality costs. It allows the identification of the place and time of the origin of a given cost. It enables evaluation of the necessity to incur a cost and its impact on improvement of work results and quality, or on optimization of quality costs in an organization (Grudowski et al., 2016; Rehacek, 2018).

By applying quality costs calculation companies can compare their own quality costs with those of other companies in the same industry. A thoroughly carried-out calculation is the foundation for a cost analysis which is to create stimuli for improving the efficiency of activities in the area of quality (Wójcik, 2014).

This calculation should embrace registering by way of booking in adequate accounts of all costs related to quality, calculating quality costs and analysis of their rates behaviour, as well as undertaking preventive and corrective measures (Hamrol, 2008).

The increase of an entity's efficiency obtained by the identification of sources of apparent deviations from quality requirements, their measurement, and the implementation of corrective actions eliminating irregularities are the main tasks of quality costs calculation (Zymonik, Hamrol, Grudowski, 2013).

The main objectives of quality costs calculation are quality management effectiveness assessment, creating the foundation for internal quality improvement programmes by identifying problems to be solved, and increase of the company's value (Toruński, 2009).

Introducing quality costs calculation brings a number of benefits to the company. The entity obtains information as to the quality costs levels generated in the entire organization, as well as in a cross section of individual areas of activity. Thanks to this knowledge, it can identify the reasons for generating costs of product non-compliance, and adjust production to customer expectations. Implementation of this calculation also allows the mobilisation of all company staff to participate in the quality management process, and is a strong stimulus for developing an incentive scheme for production supervisors. A very important advantage of introducing quality costs calculation is the possibility to lower quality costs, and the pursuit of the optimisation of their structure (Murumkar, Teli, Loni, 2018).

Quality costs calculation is a modern management tool allowing the optimisation of quality costs, and the identification of problematic activities and processes (Sadkowski, 2019). It is a decision-making account which, when run fairly, may contribute to improving quality in an organization. It is responsible for quality costs measurement, recording, registration, grouping, processing, analysing and interpreting, together with the preparation and control of the budget of these costs.

3. Classification of quality costs calculation models

The diversification of recipients of information originating from cost accounting has contributed to the development, over the years, of many different models of cost accounting (Nesterak, Kołodziej-Hajdo, Kowalski, 2017).

Among the strategic cost management models one can distinguish quality costs calculation which is characterized by the specified quality costs structure, accounts plan, procedure for running the calculation, indication of responsible individuals, and sources of information about costs, as well as by suggested improvements.

The author adopted the activity of an enterprise, for the needs of which the model was developed, as the criterion for the classification of models of this type of accounting. The choice of this criterion results from the indication of the subject of the research made by the creators of the discussed models. In the author's opinion, division by type of activity allows us to clearly identify the types of enterprises which may use such models, but also highlights the types of activities for which the model solutions are not available. Based on this criterion the following should be distinguished:

- quality costs calculation for manufacturing companies,
- quality costs calculation for service companies,
- universal quality costs calculation for enterprises.

Models created by researchers representing the Polish school of quality belong to the most important models dedicated for manufacturing companies: Ośrodek Badania Jakości Wytrobów Hutnictwa i Przemysłu Maszynowego "ZETOM" (OBiKJW PM, 1978), S. Sojak (Sojak, 1981), A. Polak (Polak, 2003), U. Balon (Balon, 2007), Ł. Kraska and D. Stadnicka (Kraska, Stadnicka, 2010), and J. Toruński (Toruński, 2011), and models by overseas authors: H.J. Harrington (Harrington, 1987), A. Chopra and D. Garg (Chopra, Garg, 2012) and T.M. Malik, R. Khalid, A. Zulqarnain, S.A. Iqbal 2016 (Malik et al., 2016). Quality costs calculation models for service companies were authored by U. Sulowska-Banaś (Sulowska-Banaś, 2013) and J. Wierzowiecka (Wierzowiecka, 2015). Universal quality costs calculation models are presented by Polish researchers: K. Lisiecka (Lisiecka, 2002), Z. Zymonik (Zymonik, 2003), M. Ciechan-Kujawa (Ciechan-Kujawa, 2005), A. Kister (Kister, 2005), and M. Foremna-Pilarska (Foremna-Pilarska, 2008), and by an overseas researcher: D.C. Wood (Wood, 2013).

Table 1 presents a classification of quality costs calculation models. They were chronologically ordered by the adopted criterion. Key variables used in comparative analysis are: availability of assumptions adopted in developing the model and a graphic scheme of procedure for keeping quality costs calculation, quality costs structure, adopted record of costs for the accounting system, an example of the quality costs accounts plan, the source of information on quality costs, bodies responsible for implementing and keeping quality costs calculation, and model enhancements the author introduced, which to date have not been used and can be regarded as innovative.

Table 1.
Classification of quality costs calculation models

Author	Year	Availability of assumptions adopted for developing the model	Graphic scheme of procedure for keeping QCC	Quality costs structure used in QCC model	Records of cost for accounting system adopted in the model	Presentation of an example of quality cost accounts plan	Source of information on costs	Bodies responsible for implementation and keeping QCC	Improvements introduced
Models of quality costs calculations for manufacturing companies									
Ośrodek Badania Jakości Wyrobów Hutnictwa i Przemysłu Maszynowego „ZETOM”	1978	Yes	Yes	PAF model	Analysis by nature/ Analysis by function	Yes	Balance sheet accounts and off-balance sheet accounts	Organization management, implementation team	Developing a quality improvement programme based on quality costs studies in the mechanical engineering industry
S. Sojak	1981	Yes	Yes	Preventive costs, quality appraisal, external and internal costs of bad quality; quality costs by product life cycle stages	Analysis by nature/ Analysis by function	Yes	Accounting records, unrecorded materials (documents from controls and audits, reports from directorial inspection, data from computer systems, error reports, complaint registers)	Organization management, quality manager, quality department, expense/ payroll department	Financial quality indicators (measures)
H.J. Harrington	1987	No	No	PAF model	Analysis by function	Yes	General ledger, error and corrections reports, guarantee reports, budgets, complaints	Implementation team and organization management	Quality costs priorities table

cont. table 1.

A. Polak	2003	Yes	Yes	PAF model and process approach	Analysis by function	Yes	Locations with investment in quality and where losses are generated	President's Representative for Quality Assessment, managers of Quality Steering, Accounting and Controlling Departments	Developing a set of accounts to record quality costs in group 5 (591, 592, 593, 594, 595, 596)
U. Balon	2007	Yes	Yes	PAF model	Analysis by function	No	Accounting documents, defects cards	Chief Accountant, Representative for Quality Assessment, Quality Costs Department	Quality costs qualification scheme, "Defects Cards", setting up "53513 Quality Costs" account
Ł. Kraska i D. Stadnicka	2010	No	Yes	Quality costs model	Analysis by nature/ Analysis by function	Yes	SAP database (process mapping cards), operational documentation	Quality Director, IT Director, Quality Manager, Implementation Team with its Leader	Schedule for implementing full account, calculation methods for quality cost values
J. Toruński	2011	Yes	No	Internal and external quality assurance costs	Analysis by nature/ Analysis by function	Yes	Documents (invoices, payrolls, information tables, etc.)	Management, quality assurance service and Accounting Department	Benchmarking and controlling
A. Chopra i D. Garg	2012	No	No	PAF model	Analysis by nature/ Analysis by function	Yes	Quality-oriented activities	Management and Quality Costs Team	System consists of two models: cost calculation and implementation of quality costs programme
T.M. Malik, R. Khalid, A. Zulqarnain, S.A. Iqbal	2016	Yes	No	PAF model	Analysis by function	Yes	Various reports (among others, scrapping, payroll) interviews, cost sheets	Management and Quality Costs Team, Quality Control Team	Detailed templates for each stage of implementation
Models of quality costs calculations for service companies									
U. Sulowska-Banaś	2013	Yes	Yes	Compliance and non-compliance costs and opportunity costs	Analysis by function	Yes	Invoices, internal calculations, internal documents proving encumbered costs	Hospital Director, Director's Representative for Quality Management, Chief Accountant,, Accounting Department, Central Sterile and Operating Theatre Management	Off-balance sheet account "53101 Quality Costs" and additional analytical accounts for recording individual quality costs, Procedure P/SZJ/8.4/01 Quality Costs Calculation

cont. table 1.

J. Wierzowiecka	2015	No	Scheme of U. Balon	PAF model	Analysis by function	Yes	Computerized accounting system and accounts	Accounting, Head of Quality Management System	Modified scheme for quality costs qualification, proposal for quality costs structure and accounts plan for laboratory and examples of such costs
Universal quality costs calculation for enterprises									
K. Lisiecka	2002	Yes	Yes	PAF model, process costs, quality loss, ISO 9004 standard	Analysis by nature/ Analysis by function	No	Listing of costs critical for quality, registration forms	Organization management, Quality Department Manager, Quality Department, Costs Department	Quality costs indicators
Z. Zymonik	2003	Yes	Yes	Process approach	Analysis by function	No	Strategic results card	Organization management	Quality costs model based on activities
M. Ciechan-Kujawa	2005	Assumptions of K. Lisiecka	Scheme of K. Lisiecka	ISO 9004 standard, ASQC	Analysis by function	Yes	Recorded and unrecorded materials	Management, Quality Management, Accounting and Controlling Departments	Developing procedure for quality costs account
A. Kister	2005	Yes	Yes	Costs of defects, assessment, and prevention model	Mixed analysis (analysis by nature – cost allocation - analysis by function)	Yes	Accounting documents	Management and Accounting Department	Model of relation of quality costs management with organization effectiveness
M. Foremna-Pilarska	2008	Assumptions of A. Kister	Scheme of A. Kister	Costs of defects, assessment, and prevention model	Mixed analysis (analysis by nature – cost allocation - analysis by function)	No	Accounting documents	Management and Accounting Department	Change of account name to “decision-making” cost account
D.C. Wood	2013	Yes	No	PAF model	Analysis by function	Yes	Financial data, accounts	Management, Quality Manager, each employee	Quality costs qualification scheme, data sheet template for quality costs, template for quality costs report

Note. own elaboration.

4. Results and discussion

Models of quality costs calculations for manufacturing companies are the results of the work of, among others, H.J. Harrington, A. Polak, Ł. Kraska and D. Stadnicka, and A. Chopra and D. Garg.

In his book *Poor-Quality Cost* H.J. Harrington presents 15 steps to take while implementing a poor quality costs system (Harrington, 1987). He suggests implementing it first in a test area in a company, which may include a production line. Poor quality costs reports, drawn up and published every month, are a key component of the system. The model may be a significant point of reference for later researchers of the subject.

In her model A. Polak presents two options to approach quality costs in a traditional perspective and through the prism of processes (Polak, 2003). The recipient can choose an option for developing quality costs calculation according to their objectives, which stands for the high flexibility of this project. The author also offers specific solutions such as cost accounts under group 5, which should be created while implementing this calculation. The whole system is based on assumptions presented in a manner comprehensible for each potential interested individual. It is characterized by a great level of detail and great attention to detail. Keeping an efficient quality costs calculation by using the model authored by A. Polak seems achievable for entities with quality costs optimization at heart, and also for those aiming at improving their processes.

A model of a comprehensive quality cost calculation for large manufacturing companies was prepared by Ł. Kraska and D. Stadnicka, and covers three stages: Initial, Analysis and Preparation, and Preparation and Implementation (Kraska, Stadnicka, 2010). A new solution available in this model is developed by the authors' work schedule for the implementation of a comprehensive calculation with precisely specified weeks of completing individual stages of the project. The entire time-line covers 21 weeks of implementation works. The cost calculation model developed in such a way is a well thought-through and designed tool. It provides comprehensive solutions such as full implementation works schedule with a description of all activities or methods for calculating quality costs. The author of the present paper believes it to be the most advanced model, which should be easy to implement in all manufacturing companies. Its only shortcoming is the lack of all assumptions used for its development collected in one place.

The quality costs calculation system for industrial enterprises authored by A. Chopra and D. Garg is formed by two models: the quality cost calculation model and the model for quality costs programme implementation (Chopra, Garg, 2012). It is characterized by simplicity universality and can be applied across the entire industry. This makes it an interesting alternative to other models. A lack of clearly defined model assumptions is not its strong suit, and calls for further development in this respect.

U. Sulowska-Banaś prepared a quality costs calculation model dedicated to service companies. The entire procedure of this account can be found in document P/SZJ/8.4/01 and is meant for Public Autonomous Health Care Management Units, and covers: Central Sterile (CS), Operating Theatre (OT), Cost Accounting Department (Sulowska-Banaś, 2013). The procedure consists of seven stages. The model by U. Sulowska-Banaś is a comprehensive solution for hospitals. The entire procedure, scope of responsibilities of persons liable, plan of quality costs accounts, and rules for calculating the quality cost index are described in detail and presented in document P/SZJ/8.4/01 and its attachments.

Universal quality costs calculation models for companies are being developed, among others, by K. Lisiecka, A. Kister and D.C. Wood.

The next stages of creating and implementing quality costs calculation for a company accountancy system are presented by K. Lisiecka in her model (Lisiecka, 2002). In detailed procedures the author explains how to proceed when implementing this system. At each stage departments responsible for execution are identified. Each action has its initial assumptions to meet and results obtained after completion. The whole is logical and clear for a recipient who plans on introducing quality costs calculation in their organization.

In her procedure of quality costs calculation A. Kister distinguishes the four following stages: recognition, analysis, optimization and reporting (Kister, 2005). Her quality costs calculation presents assumptions in great detail. As opposed to K. Lisiecka and A. Polak, the researcher does not distinguish departments responsible for the completion of individual stages. Therefore, she leaves a certain freedom of choice for the interested organization. The model by A. Kister is accurately prepared with detailed assumptions as its strength. However, it is different from the previous models.

Also, D.C. Wood prepared a universal quality costs calculation model for companies. The proposed system for qualifying quality costs is one of its great assets (Wood, 2013). The author also created a template for a quality costs data sheet and a quality costs report in monthly and annual breakdowns. The assumptions adopted while developing the model are very general, without specific guidelines or a system visualizing the quality costs calculation procedure. D.C. Wood describes in detail all steps necessary for implementing this calculation. However, he does not indicate the people or teams responsible for their implementation, nor does he specify to which enterprises this offer is directed. This concept is interesting, but the missing aspects need to be supplemented.

In light of the above considerations and prepared classification of quality costs calculation models, it must be found that:

1. The quality costs calculation model is made up of quality costs structure, accounts plan, scheme of procedure for keeping this account together with indication of responsible individuals, sources of information about quality costs, and suggested improvements.
2. Type of company activity is the main criterion for the classification of the quality costs calculation.

3. The greatest number of models was studied for manufacturing companies.
4. There is no quality costs calculation model dedicated for service companies. Only organizations providing services in healthcare have such a calculation model, developed by U. Sulowska-Banaś.
5. Universal quality costs calculation models are the result of work carried out by: K. Lisiecka, Z. Zymonik, A. Kister, M. Ciechan-Kujawa and D.C. Wood.
6. The majority of researchers provide clearly specified assumptions, with the exception of H.J. Harrington, Ł. Kraska and D. Stadnicka, A. Chopra and D. Garg, and J. Wierzowiecka.
7. H.J. Harrington, D.C. Wood and T.M. Malik, R. Khalid, A. Zulqarnain and S.A. Iqbal do not ensure any graphic scheme of the procedure.
8. Models by M. Ciechan-Kujawa, M. Foremny-Pilarska and J. Wierzowiecka are further elaborations on projects by K. Lisiecka, A. Kister and U. Balon, using their assumptions and operating schemes.
9. The PAF Model is the dominating quality costs structure.
10. Analysis by function is the most frequently adopted in grouping costs by authors of the models.
11. Most models provide example classifications of quality costs in the form of company accounting plans for quality costs.
12. Accounting documents, accounting records, defect cards, error reports, and complaint reports are the most important sources of information on quality costs.
13. Responsibility for implementing and keeping quality costs calculation is on the management, quality manager and implementation team. The implementation process should be carried out in co-operation with the accounting department and controlling department.
14. Virtually all of the models provide new tools, such as quality costs priority table (H.J. Harrington), quality costs indexes (K. Lisiecka), quality costs qualification scheme (U. Balon, D.C. Wood), implementation works schedule (Ł. Kraska and D. Stadnicka), defect cards (U. Balon), and detailed templates for implementation stages (T.M. Malik, R. Khalid, A. Zulqarnain and S.A. Iqbal), which may ensure more efficient work organization in the course of the quality costs calculation procedure.
15. The most advanced quality costs calculation models belong to A. Polak and Ł. Kraska, and D. Stadnicka.
16. The greatest number of concepts was developed after 2000.
17. Only model by T.M. Malik, R. Khalid, A. Zulqarnain and S.A. Iqbal provide adequate templates for application at each stage of quality costs calculation implementation.

5. Summary

To sum up, it should be stated that the adopted classification criterion, in the form of the type of activity carried out by an enterprise, arranges the selected quality costs calculation models in a comprehensible and clear manner.

The presented and discussed models of this calculation by Polish and foreign authors can be characterized by simplicity and attention to detail. Each of the projects, to a greater or lesser extent, presents further steps to take in developing quality costs calculation.

The authors use tried and tested models, and the experience of their predecessors, which they modify for their needs. Unfortunately, some approaches' clearly specified assumptions are missing, which may lead to misunderstandings and errors in the course of implementation.

The great number of models confirms researchers' interest in the subject of quality costs calculation. The procedure by T.M. Malik, R. Khalid, A. Zulqarnain and S.A. Iqbal is worth noting and recommending as it may be of particular help in organizations without any experience in the area of quality costs. Large companies, in turn, should apply the study prepared by Ł. Kraska and D. Stadnicka.

What is most visible is the lack of a quality costs calculation model which could be used in any service company regardless of the type of provided services. The procedure created by U. Sulowska-Banaś can be used only in hospitals. The author recommends for the direction of future research the undertaking of works on creating a universal quality costs calculation model for service companies.

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